Testing and Evaluation of Four-Dimensional Ensemble Variational Data Assimilation for Regional Weather Forecasts

Hui Shao[1,3], Ming Hu[2,3,4], Chunhua Zhou[1,3], Kathryn Newman[1,3], Xin Zhang[2,3,4], and Christina Holt[2,3,4]

[1] National Center for Atmospheric Research

[2] NOAA/ESRL Global Systems Division

[3] Developmental Testbed Center

[4]CU Cooperative Institute for Research in the Environmental Sciences

The hybrid Ensemble Variational (EnVar) data assimilation technique uses a combination of static contributions and an ensemble of non-linear model states to estimate background error covariances over the assimilation time window. This technique brings flow-dependent features into analyses from a traditional variational data assimilation system, which uses purely static background error information. The ensemble spread at each location and for each variable reflects the uncertainty of the first guess. Incorporation of this flow-dependent probabilistic information into the data assimilation system allows for forcing the analysis closer to the observations (when there is less confidence on the first guess) or closer to the model background (when there is more confidence on the first guess), which improves the quality of the model initialization and forecast.

The same ensemble can also be used to prescribe four-dimensional (4D) increments, replacing the integration of tangent linear and adjoint models as applied in standard 4D-Var. The 4D EnVar analysis is a localized linear combination of nonlinear trajectories of ensemble perturbations. These localized ensemble trajectories define the 4D probability density function (PDF) of possible increments. The maintenance costs for such a 4D EnVar or hybrid 4D EnVar system are significantly reduced in comparison with a standard 4D-Var, especially when ensemble forecasts are already run at many operational centers. NCEP is testing such a system for its Global Forecasting System (GFS) with plans for implementation in 2016.

To assist with the transition of this technique to regional applications, the Developmental Testbed Center (DTC) is collaborating with the system developers at NCEP and NOAA ESRL to test NCEP's 4D hybrid EnVar system for the NOAA Rapid Refresh (RAP) application. The DTC has examined existing capabilities in this system and performed multiple experiments to test the experimental 4D hybrid EnVar system against the control experiments following the RAP data assimilation configurations (3D hybrid). This paper highlights initial results from this effort, and provides insight into the path forward for optimizing the use of 4D hybrid EnVar. The potential outcome of this work is the improvement of initial conditions for regional forecasts through use of this advanced data assimilation technique and, eventually, help NOAA and its partners provide more accurate forecast information to society.